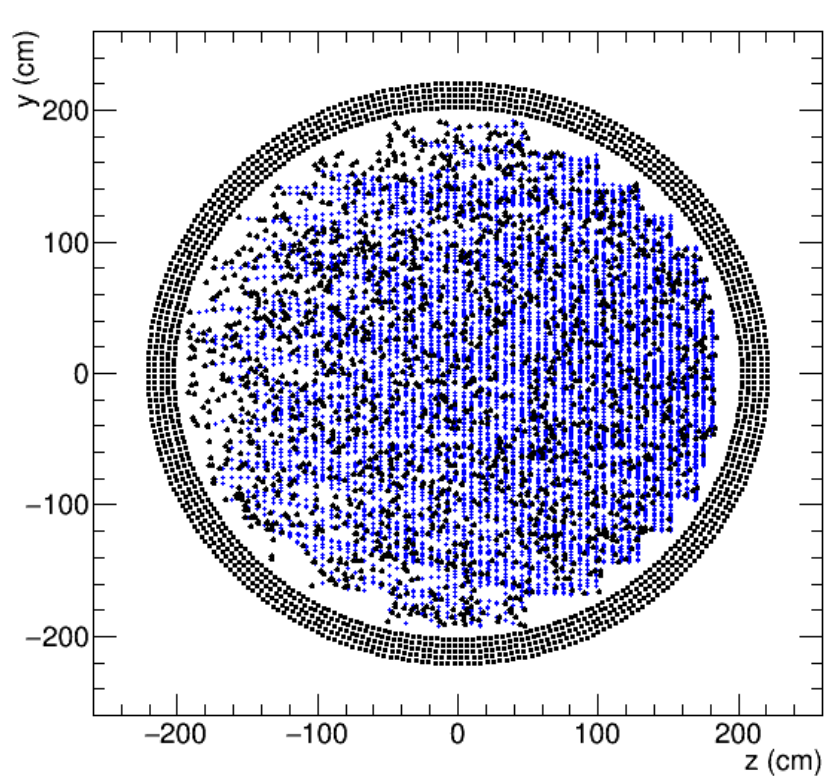# ν-event reconstruction in the KLOE-STT layout

P. Bernardini, A. Surdo
Università del Salento and INFN, Lecce, Italy

Frascati, March 18th, 2019
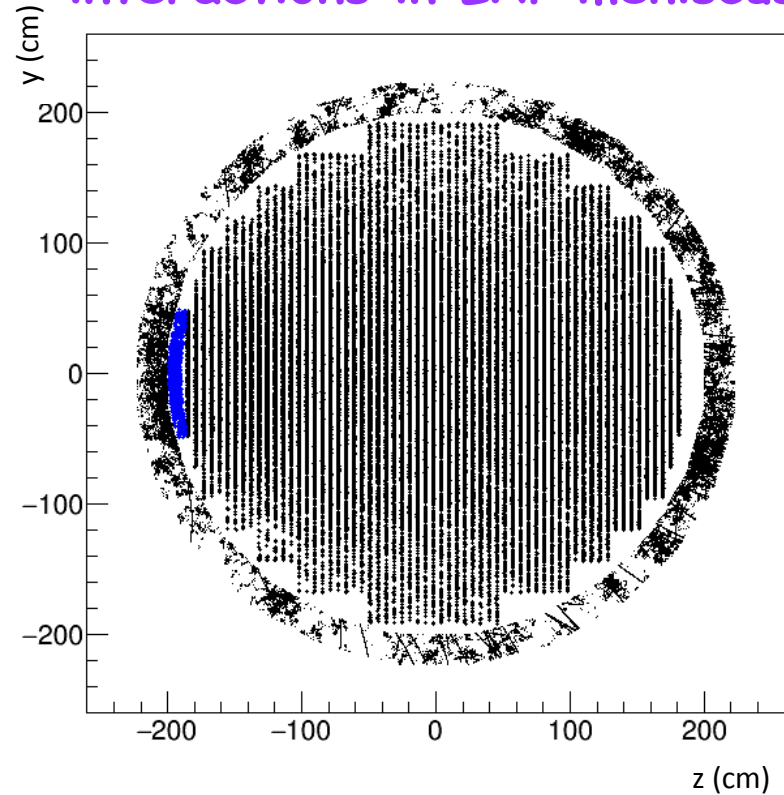
Fluka simulation

"STT-only" layout
interactions in the tracker

"LAr+STT" layout
interactions in LAr meniscus

- **Interaction vertices in STT**
- **STT digits (Y-Z view)**

- **Interaction vertices in LAr**
- **STT digits (Y-Z view)**

Reconstruction strategy (without MC truth)

- **Step 0 - Vertex reconstruction based on STT-hit topology**

- Track finding (global transform method)

- Linear or circle fits of the tracks

- **Step 1 - Vertex reconstruction from crossing of 2 most rigid tracks**

- Possible repetition of the procedure
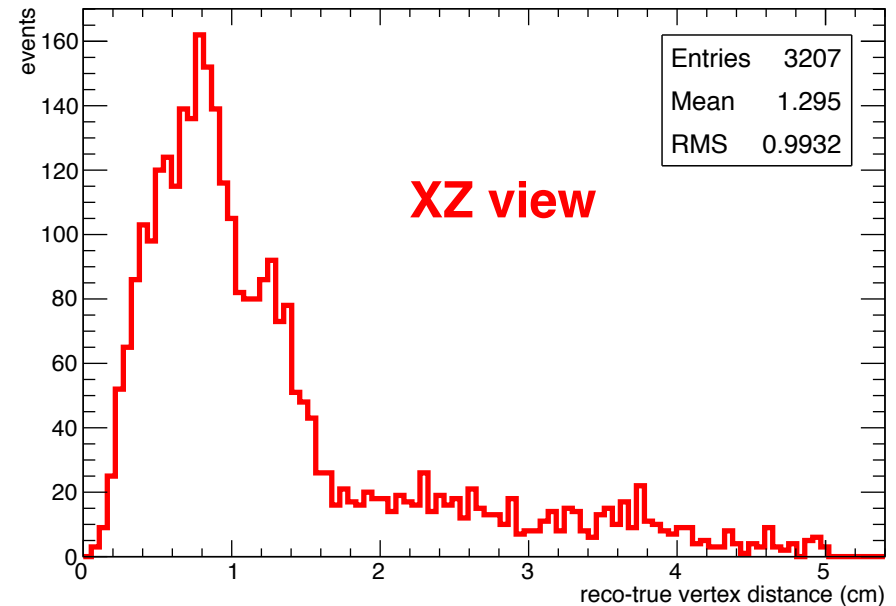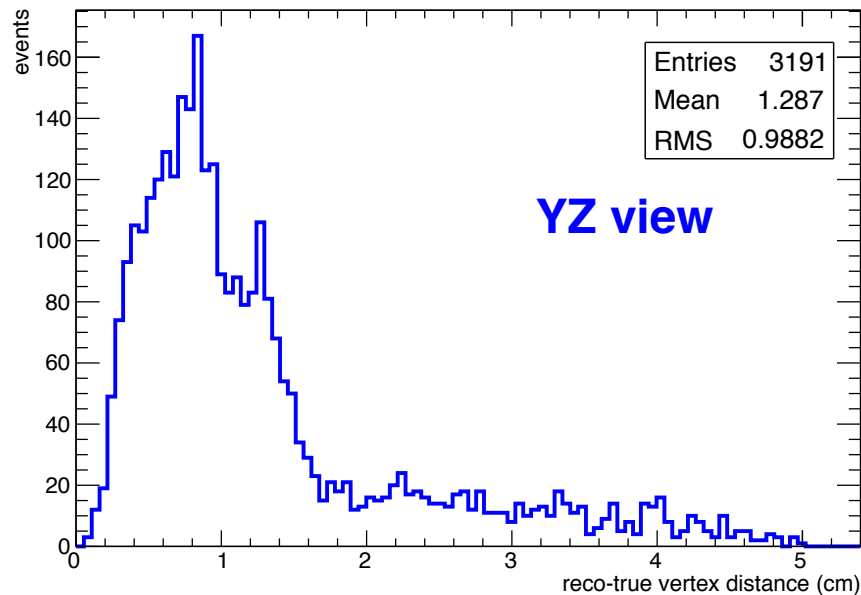
in both views (Y-Z and X-Z)

- Track matching $\Rightarrow$ 3D track

- $p_\perp$ from Larmor radius
- dip-angle λ from x-vs-ρ fit

momentum estimate $p = p_\perp / \cos \lambda$

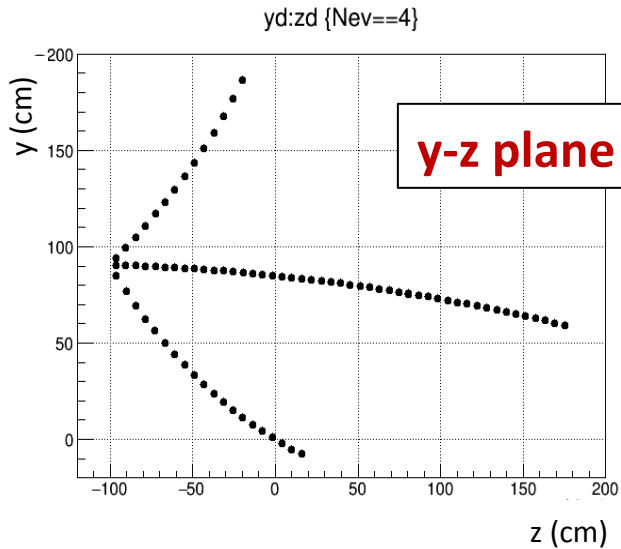# Step 0 – Rough vertex reconstruction based on topologycal criteria

◆ **STT spread profile on X and Y axes vs Z coordinate**
◆ **removing of secondary vertices**
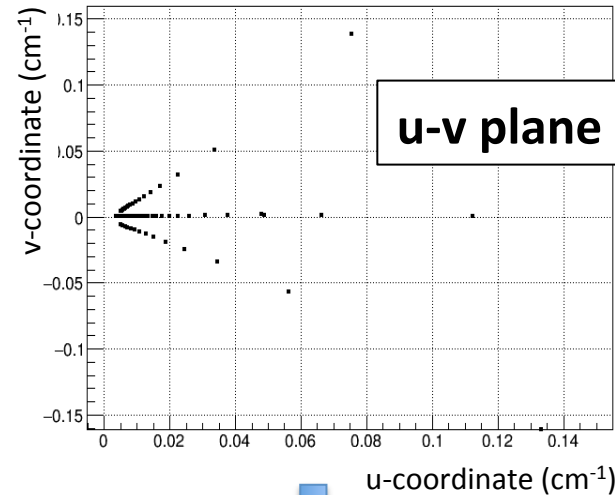◆ **first (in z) STT hit in case of single-track events**

Track finding and reconstruction
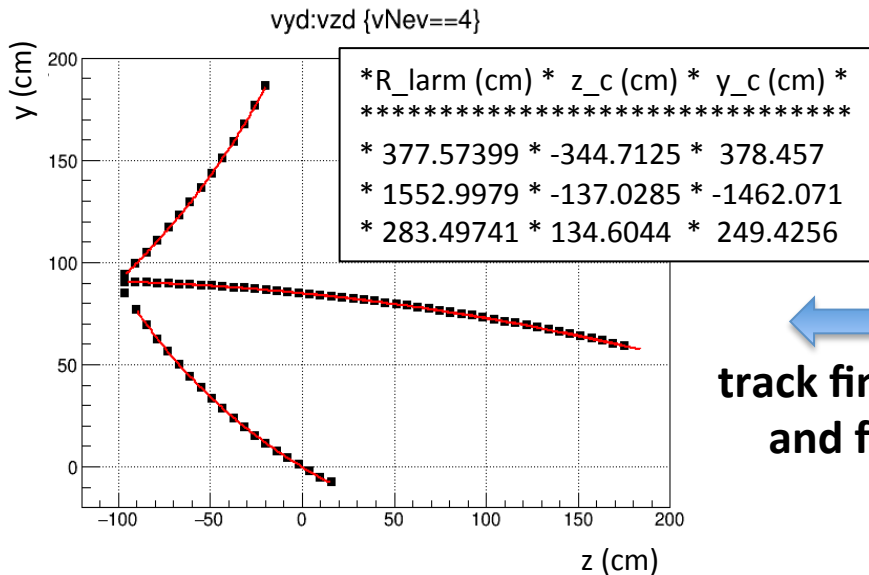
$$u = +(z-z_V) / [(z-z_V)^2 + (y-y_V)^2]$$
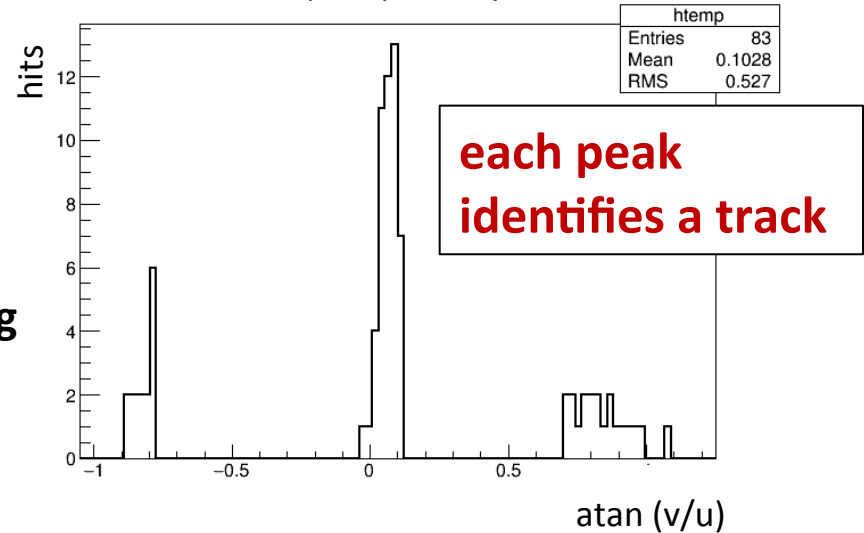$$v = -(y-y_V) / [(z-z_V)^2 + (y-y_V)^2]$$

yd:zd {Nev==4}

y-z plane

u-v plane

u-v plane

global transform method

$$\phi = atan(v/u)$$

vyd:vzd {vNev==4}

```
*R_larm (cm) *  z_c (cm) *  y_c (cm) *
*****************************
* 377.57399 * -344.7125 *  378.457
* 1552.9979 * -137.0285 * -1462.071
* 283.49741 * 134.6044  *  249.4256
```

track finding and fits

vphitrk {vNev==4}

htemp	
Entries	83
Mean	0.1028
RMS	0.527

each peak identifies a track

atan (v/u)

Each trajectory is fully reconstructed!

5

STT-Only – Error on Vertex reconstruction – Step 1

YZ view

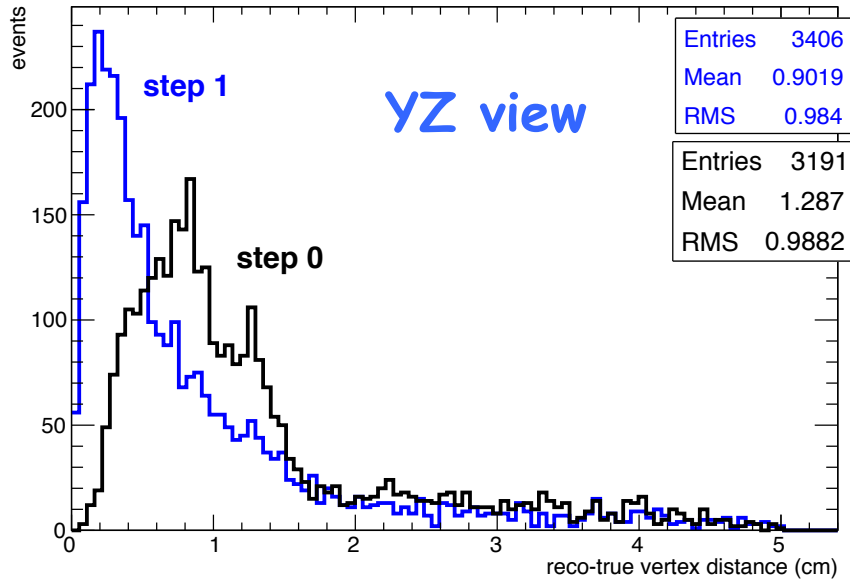|	Entries	3406
step 1	Mean	0.9019
	RMS	0.984

	Entries	3191
step 0	Mean	1.287
	RMS	0.9882

events — reco-true vertex distance (cm)

XZ view

	Entries	3285
step 1	Mean	0.9356
	RMS	0.9979

	Entries	3207
step 0	Mean	1.295
	RMS	0.9932

events — reco-true vertex distance (cm)

3D

	Entries	3246
step 1	Mean	0.9656
	RMS	1.018

	Entries	3082
step 0	Mean	1.43
	RMS	1.021

events — reco-true vertex distance (cm)
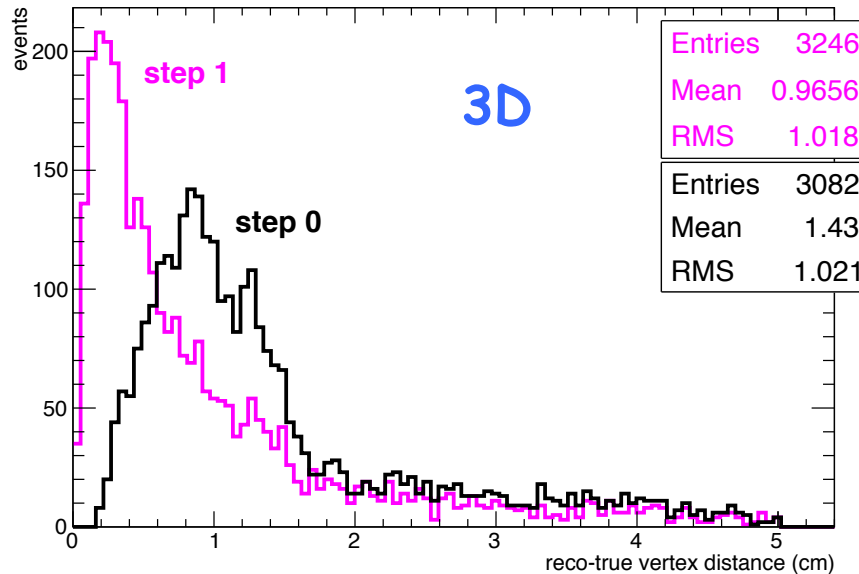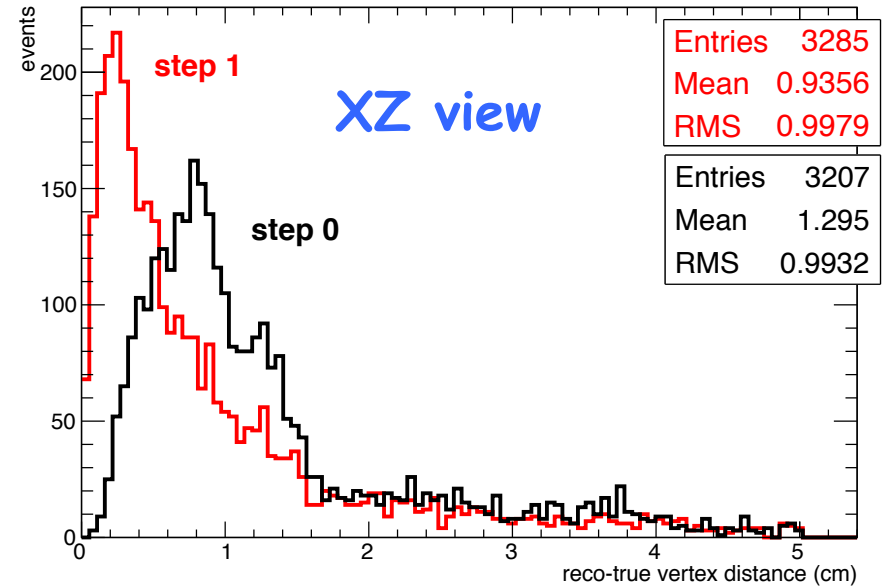
significant improvements are possible (and necessary)

STT-Only – Error on Vertex reconstruction – Step 1

Momentum estimate for reconstructed tracks

- $p_\perp$ from Larmor radius after circular fit
  in the bending (y-z) plane

- dip-angle (λ) from linear fit in the x-ρ plane

  $\rho = z \cos \phi_0 + y \sin \phi_0$
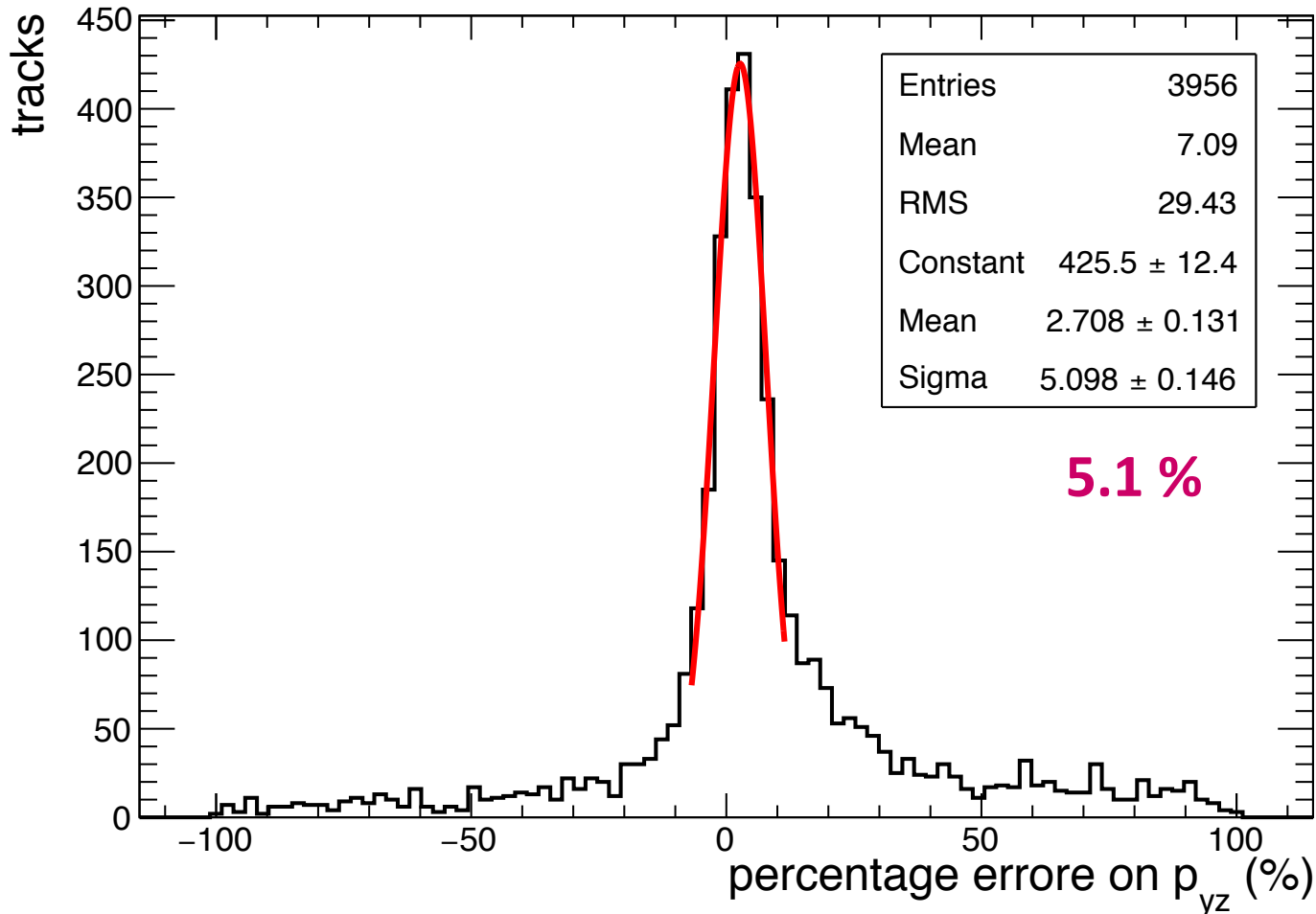 $\phi_0 = atan[-(z_0-z_c)/(y_0-y_c)]$
  z_0,y_0 coordinates of 1st hit on the track
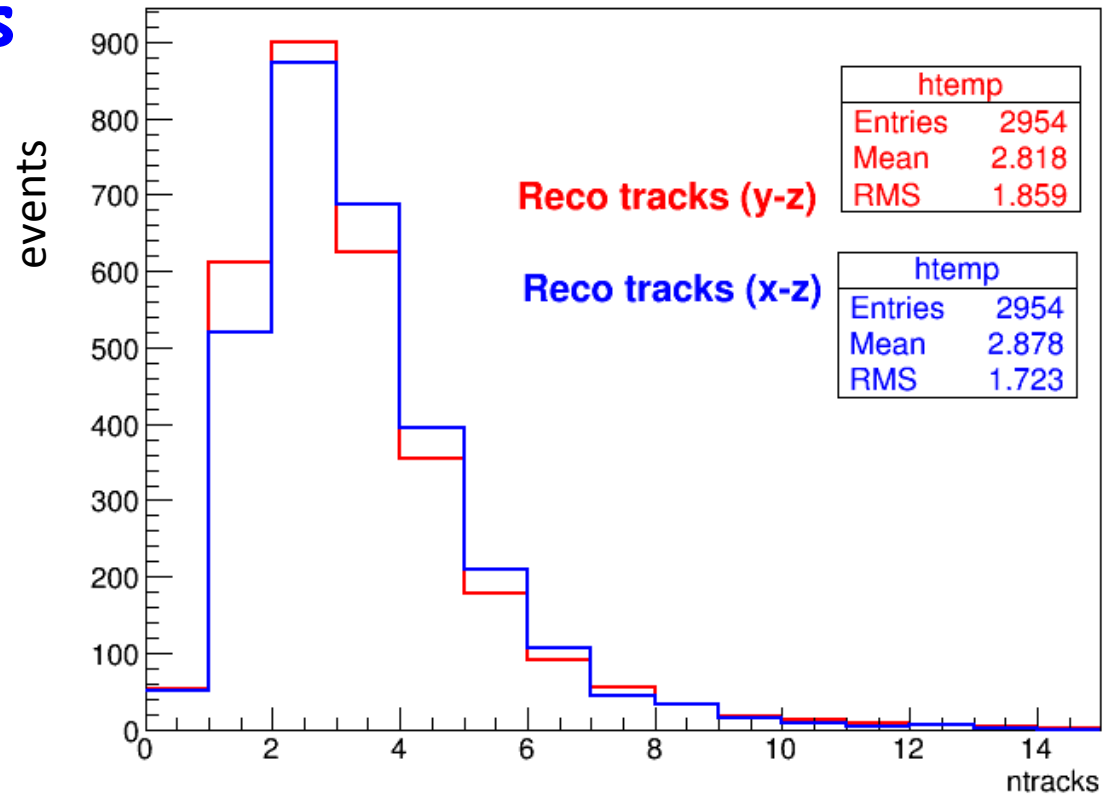 z_c,y_c coordinates of the center of fit-circle

- momentum measurement: $p = p_\perp / \cos \lambda$

- 3D-track is needed $\Rightarrow$ matching of tracks
  in y-z and x-z views

Error on momentum in the bending plane (p$_{yz}$) track-by-track with at least 10 STT hits (events with track multiplicity up to 3)

Entries	3956
Mean	7.09
RMS	29.43
Constant	425.5 ± 12.4
Mean	2.708 ± 0.131
Sigma	5.098 ± 0.146

5.1 %

tracks

percentage errore on p$_{yz}$ (%)

Track multiplicities

STT target

htemp	
Entries	2954
Mean	2.818
RMS	1.859

Reco tracks (y-z)

htemp	
Entries	2954
Mean	2.878
RMS	1.723

Reco tracks (x-z)

(1) Sample of events with 1 reco track on both views:

 12% **(QE: 68%, RES: 10%, DIS: 22%)**

(2) Sample of events with 2 reco tracks on both views:

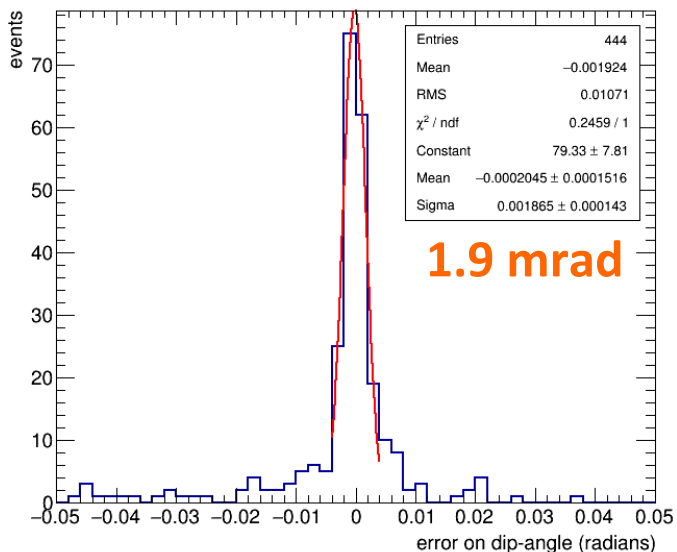 **18%** **(QE: 43%, RES: 21%, DIS: 36%)**

Single-track sample
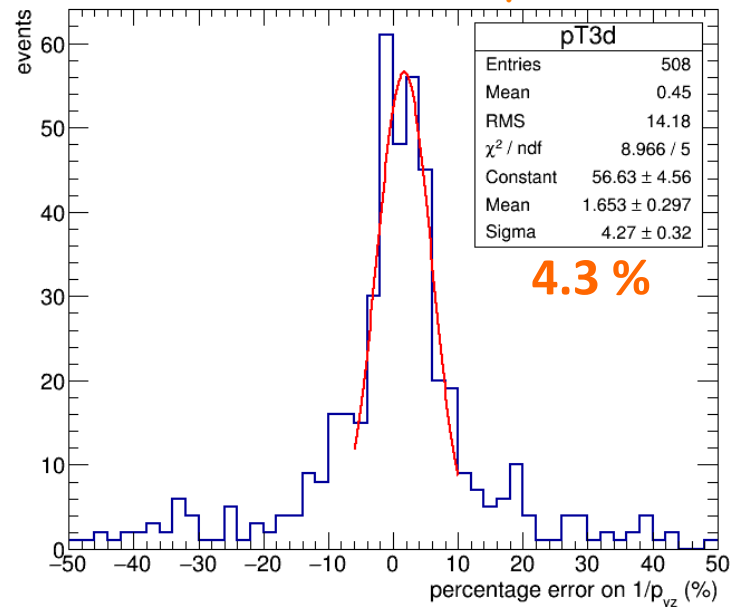
Only 1 reconstructed track on both views:

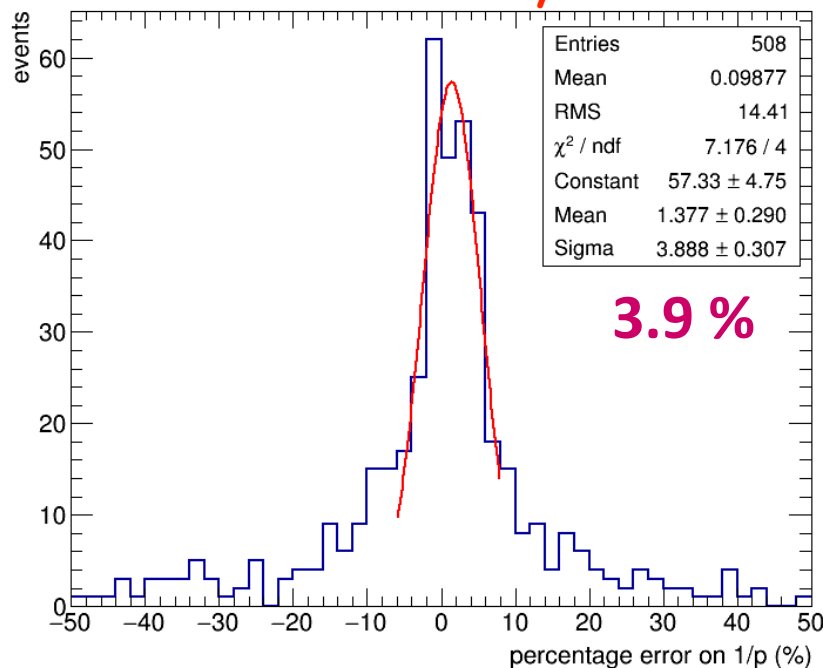   **87% → muons**

      9% → protons

      4% → pions or nuclear fragments

Error on p_{yz}

pT3d	
Entries	508
Mean	0.45
RMS	14.18
χ^2 / ndf	8.966 / 5
Constant	56.63 ± 4.56
Mean	1.653 ± 0.297
Sigma	4.27 ± 0.32

4.3 %

Error on dip-angle (λ)

Entries	444
Mean	−0.001924
RMS	0.01071
χ^2 / ndf	0.2459 / 1
Constant	79.33 ± 7.81
Mean	−0.0002045 ± 0.0001516
Sigma	0.001865 ± 0.000143

1.9 mrad

Error on $p = p_{yz}$ / cos λ

Entries	508
Mean	0.09877
RMS	14.41
χ^2 / ndf	7.176 / 4
Constant	57.33 ± 4.75
Mean	1.377 ± 0.290
Sigma	3.888 ± 0.307

3.9 %

Neutrino beam external interactions

The removal of this background has been studied by means of the <u>vertex reconstruction</u> and exploiting the time resolution of ECal (~0.25 ns) and STT (~1.5 ns)

Simulated 19×10^3 external interactions (in yokes, cryostat and calorimeter)
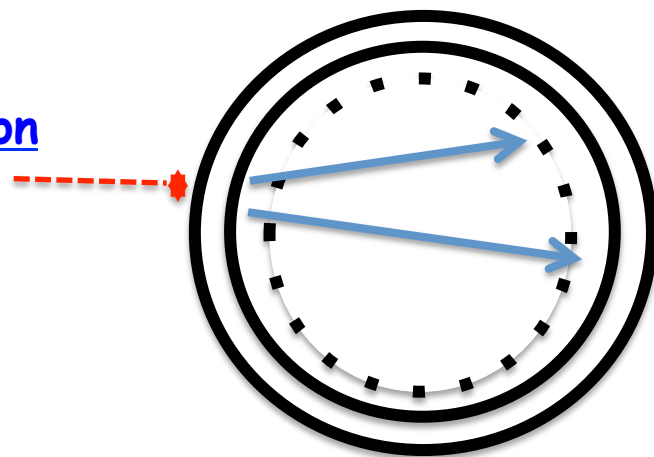
Removal criteria:

➢ Accepted events in the fiducial volume (reco vertex 30-cm inside the STT volume)

➢ Topological cut (ECal hits w.r.t. vertex)

➢ Time sequence of ECal and STT hits

} ECal as a veto

➢ Angle of the total reconstructed momentum $\theta_z < 0.5$ rad

Result (to be improved)   Signal/Noise = 3.9

Conclusions

❑ **Preliminary reconstruction of the CC events has been implemented without MC "truth" (vertex, track finding, fit, single-track momentum)**

❑ **Similar results in STT-only and LAr+STT layout.**

❑ **Many improvements of the reconstruction are possible and necessary (Kalman filter, track association and so on)**

❑ **Removal of external beam-neutrino events has been implemented**

Backup slides

STT hit "digitization"

- **Two separate samples of ν interactions (for the two detector layouts) generated with FLUKA MC-simulation**

- **STT hits on 63 planes in each view (X-Z and Y-Z) provided by the MC-simulation for charged particles**

- **STT-resolution of 0.2 mm simulated by means of Gaussians on X and Y coordinates**

- **For any charged particle MC-track:**

  hits for each STT plane are grouped to get the "STT-digits" in X-Z and Y-Z views (digit coordinates from the average of hit coordinates)

"STT-Only" detector

MC (complete) event

Side view (Z-Y)
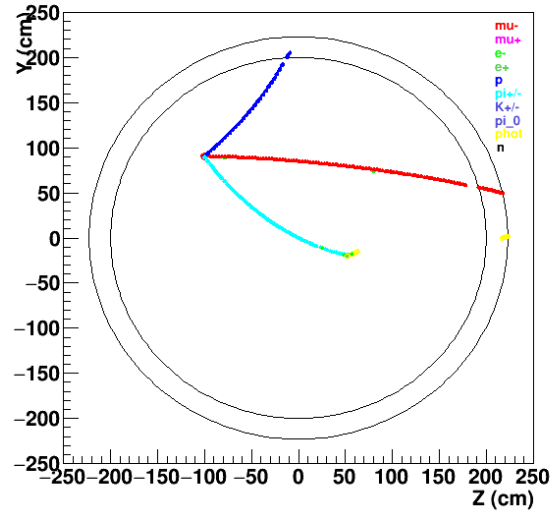
Top view (X-Z)

"STT-Digitized" event

yd:zd {Nev==4}

Another example

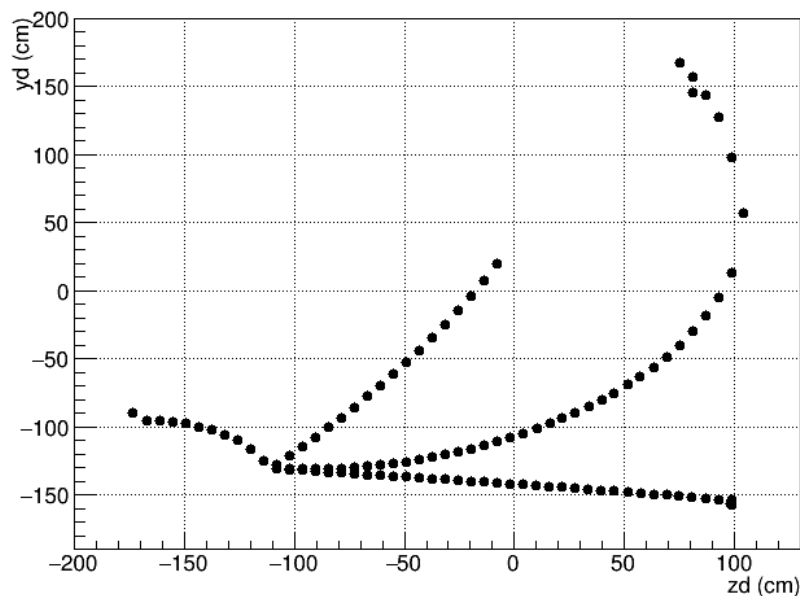yd:zd {Nev==5}

vvd:vud {vNev==5}
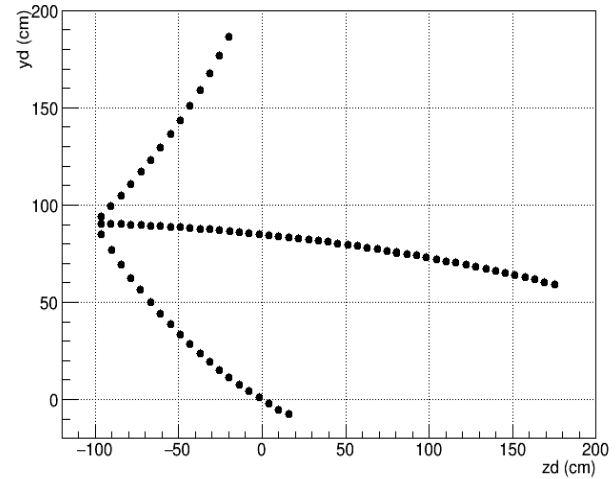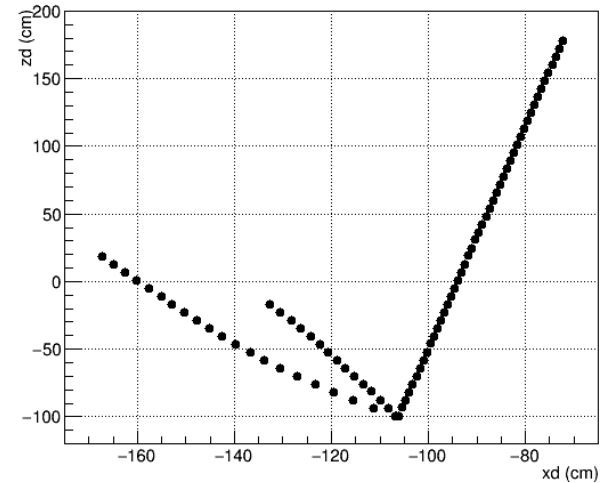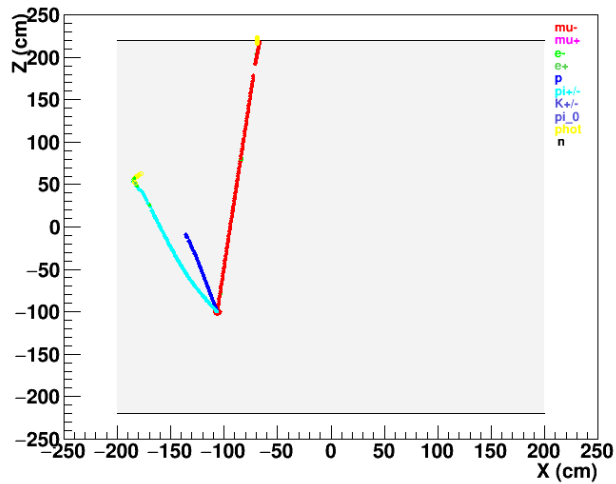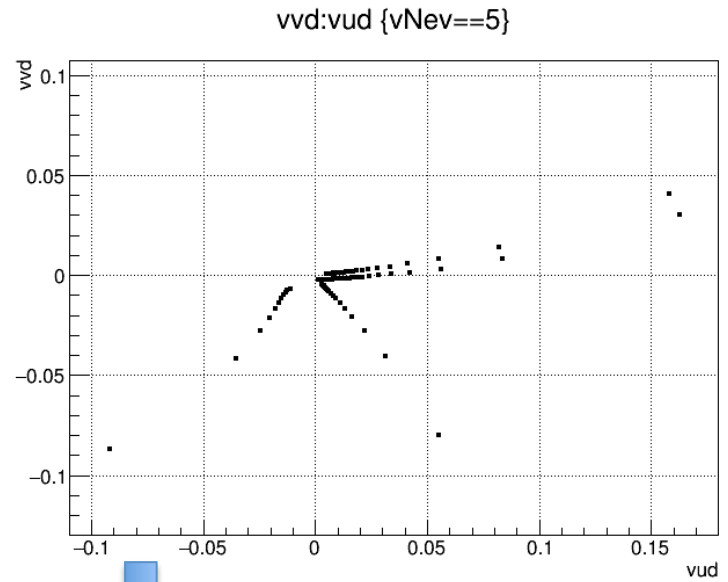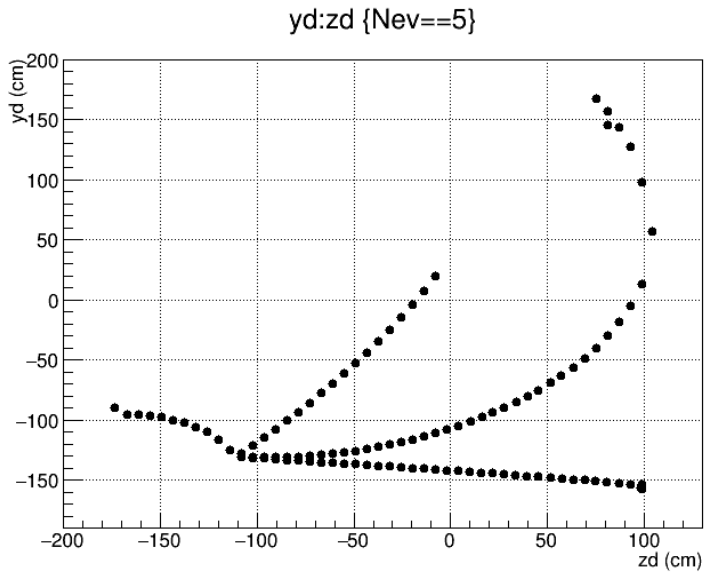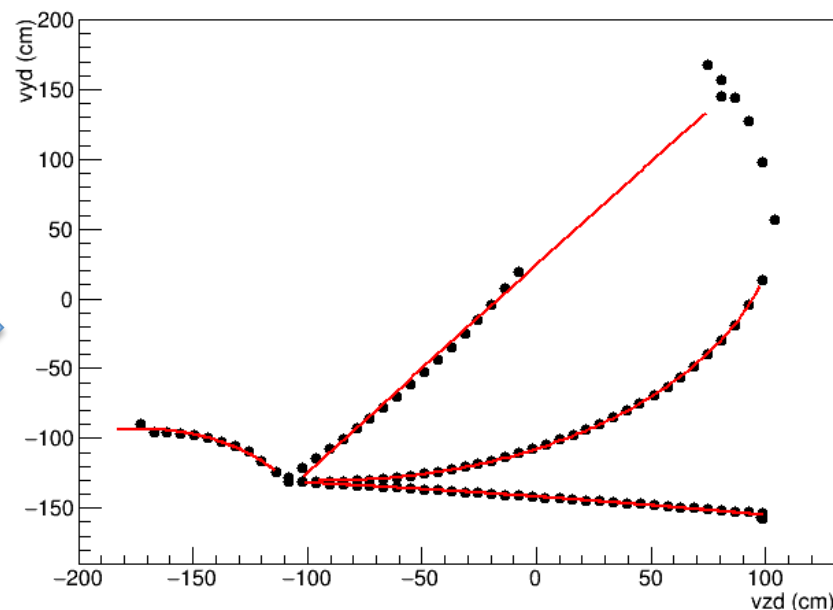

vphitrk {vNev==5}
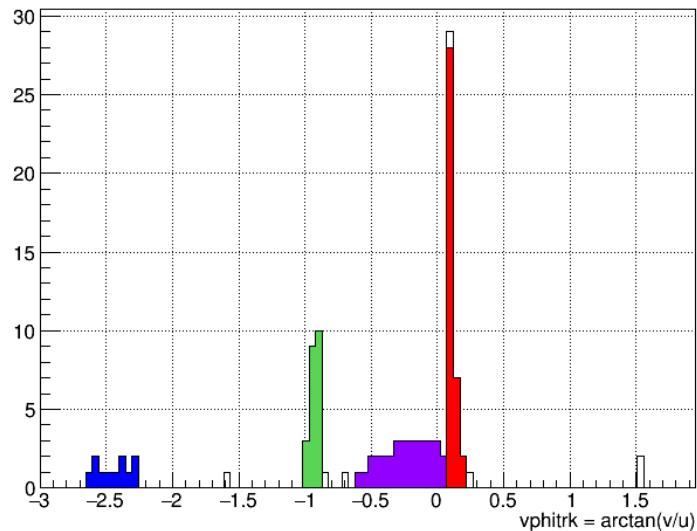
$\phi=\arctan(v/u)$

4 peaks (tracks) identified

Event Track recontruction

yd:zd {Nev==5}

vyd:vzd {vNev==5}

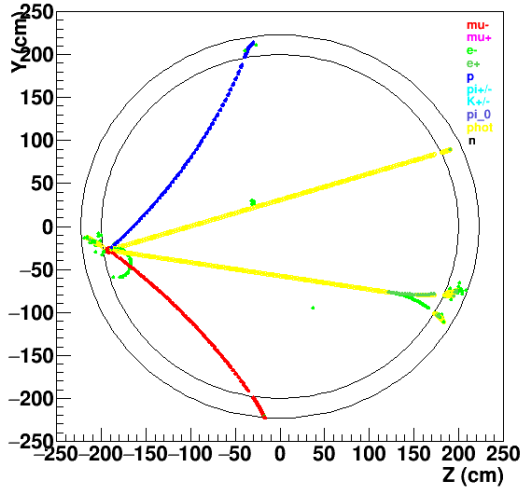| itrk *	nhitrack *	tcirc_fla *	tR_larm *	tz_c *	ty_c *
1 *	11 *	1 *	74.007993 *	-173.6376 *	-167.3248
2 *	22 *	1 *	19038.232 *	15776.671 *	-10631.27
3 *	34 *	2 *	200.39639 *	-93.50466 *	69.810156
4 *	37 *	1 *	3010.6174 *	-346.8869 *	-3132.435

4 tracks are (almost) reconstructed …
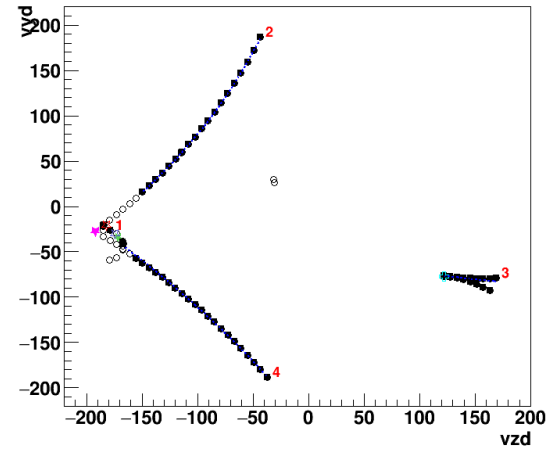
"LAr target+STT" detector

MC (complete) event
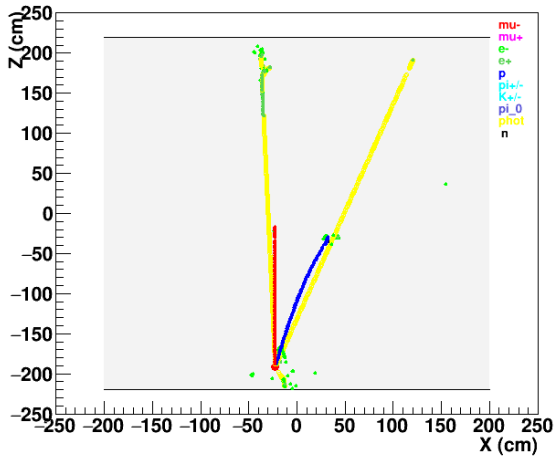
"STT-Digitized" event
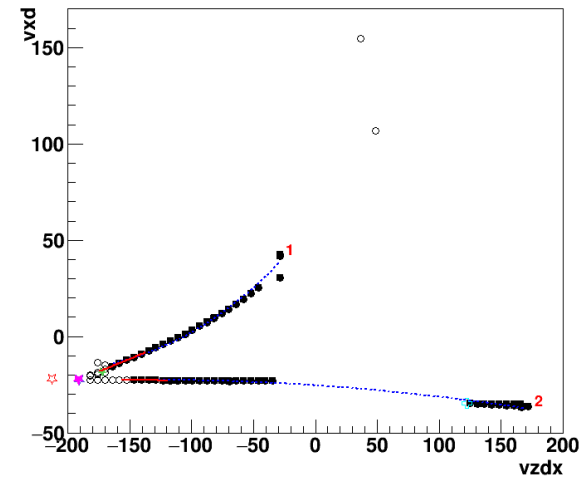
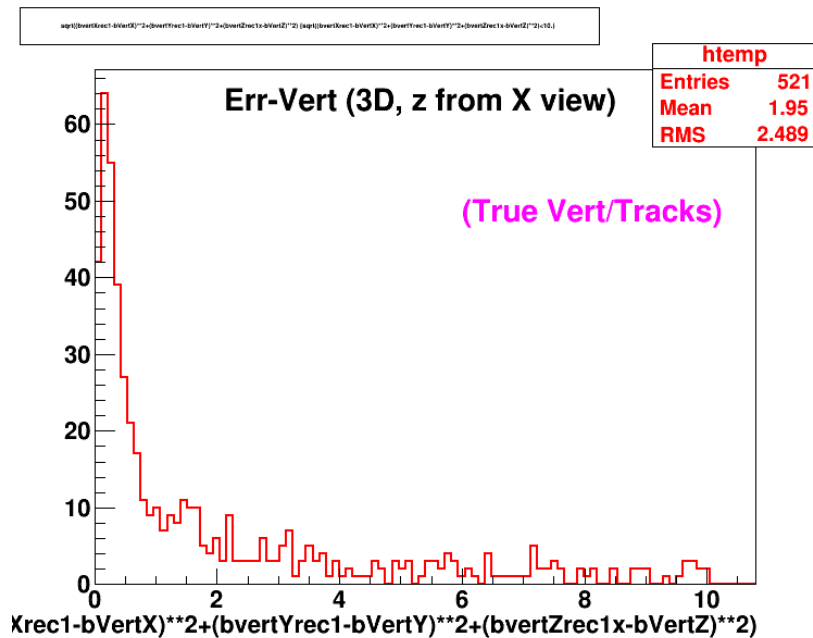# "LAr target + STT": Error on Vertex reco (Step 1)
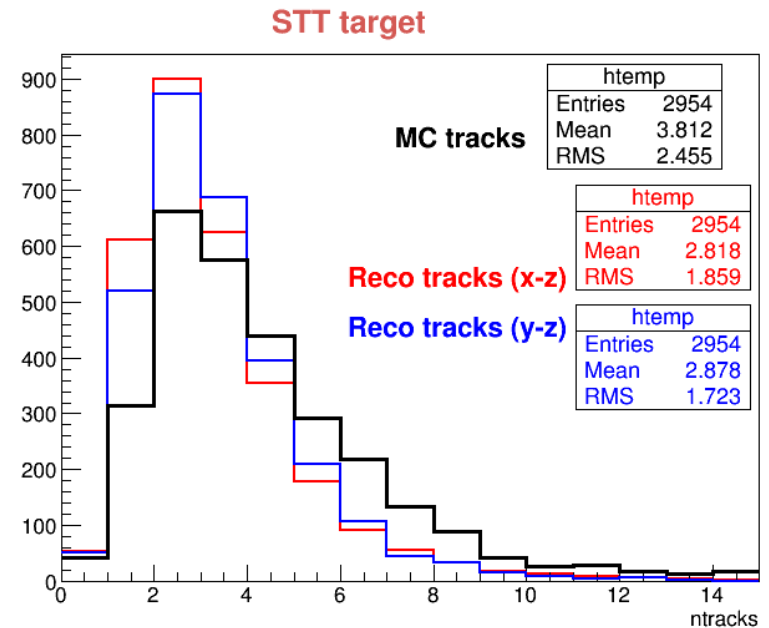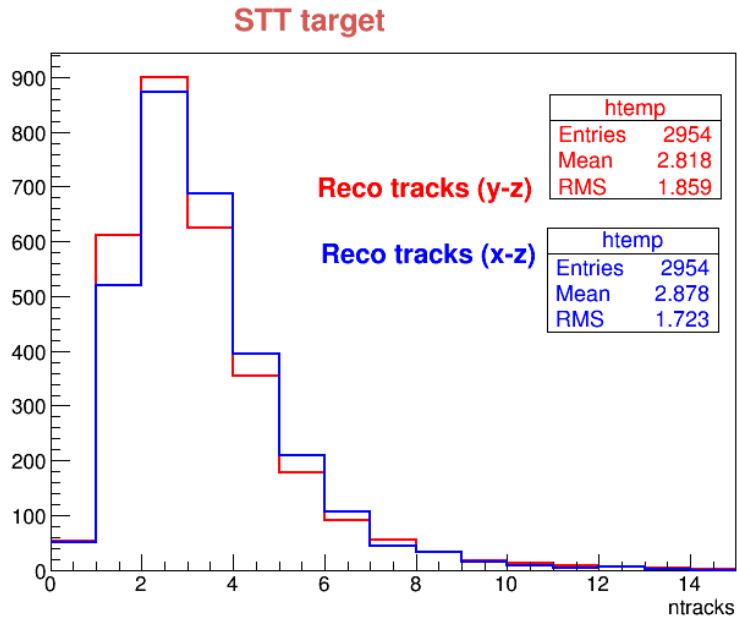
As benchmark ...

Use:
True Vertex and True (MC) tracks

Then:
Fit all tracks and Reconstruct vertex from most rigid track-crossing (step 1)
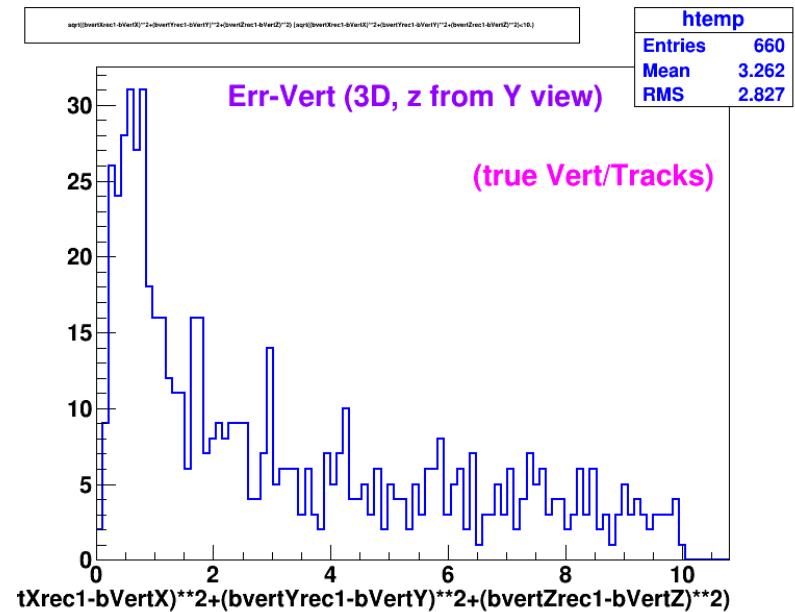
STT-only layout: track multiplicities

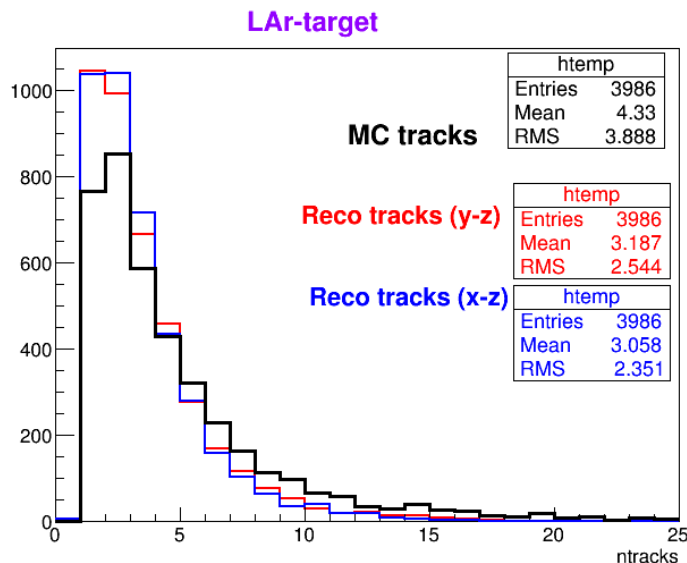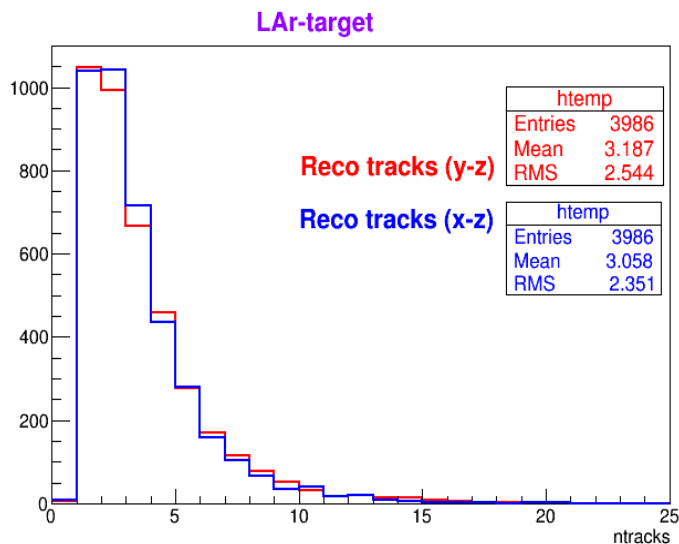**(1) Sample of events with 1 reco track on both views:**

    12% **(QE: 68%, RES: 10%, DIS: 22%)**

(2) Sample of events with 2 reco tracks on both views:

    18% (QE: 43%, RES: 21%, DIS: 36%)

Matching the tracks in the two views …

Track multiplicities (LAr-target layout):

MC tracks: charged particle with ≥3 STT-hits

(1) Sample of events with 1 reco track on both views:

21% **(QE: 68%, RES: 17%, DIS: 15%)**

(2) Sample of events with 2 reco tracks on both views:
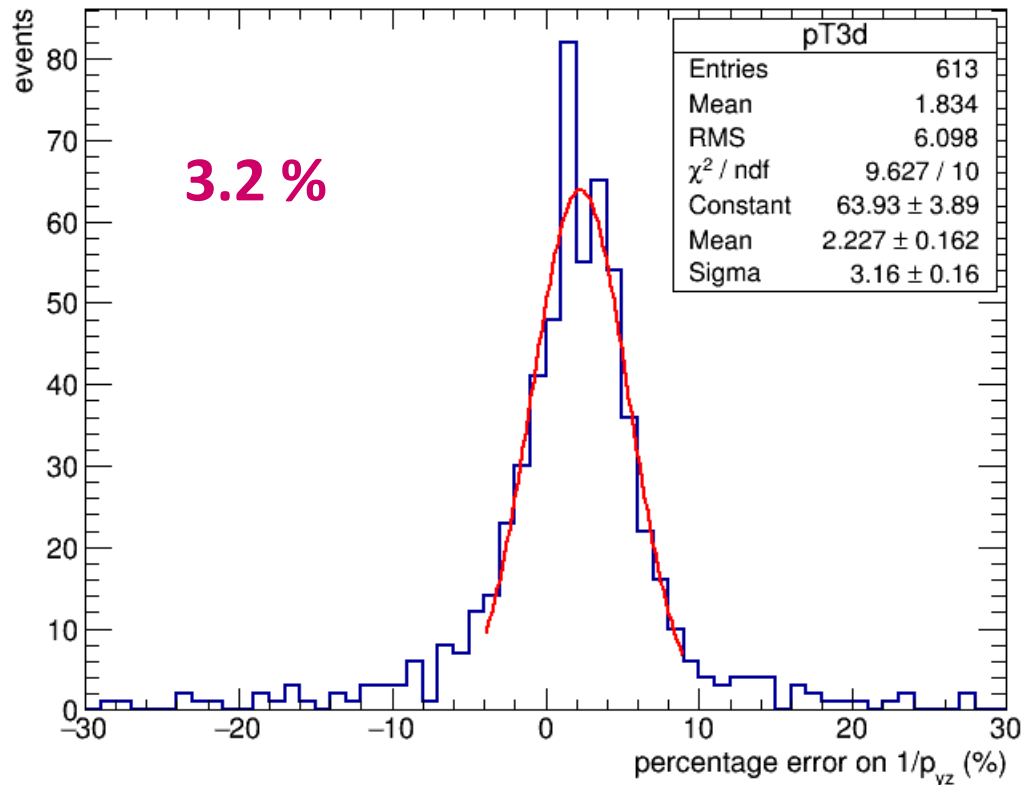
14% **(QE: 14%, RES: 22%, DIS: 64%)**

LAr-target layout: event sample (1)

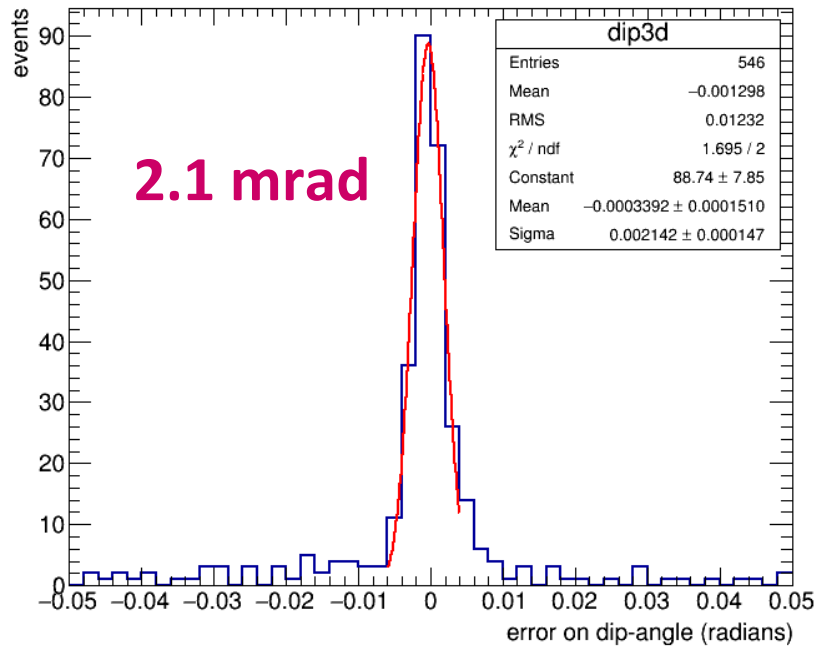**1 Reconstructed track on both views:**

94% → muon, 5% → proton, 1% → pion or nuclear fragment

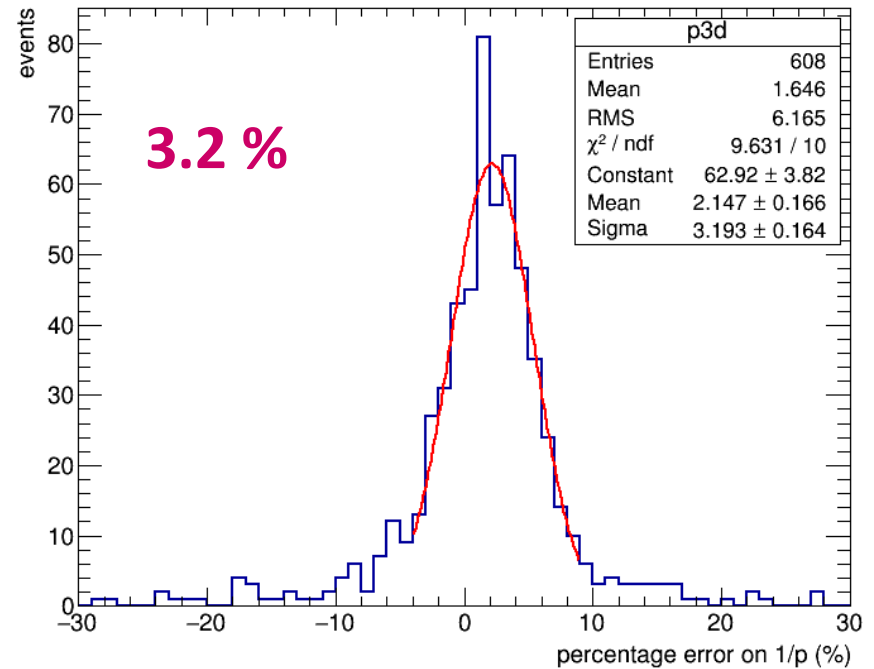## Error on $p_\perp$ from Larmor radius:
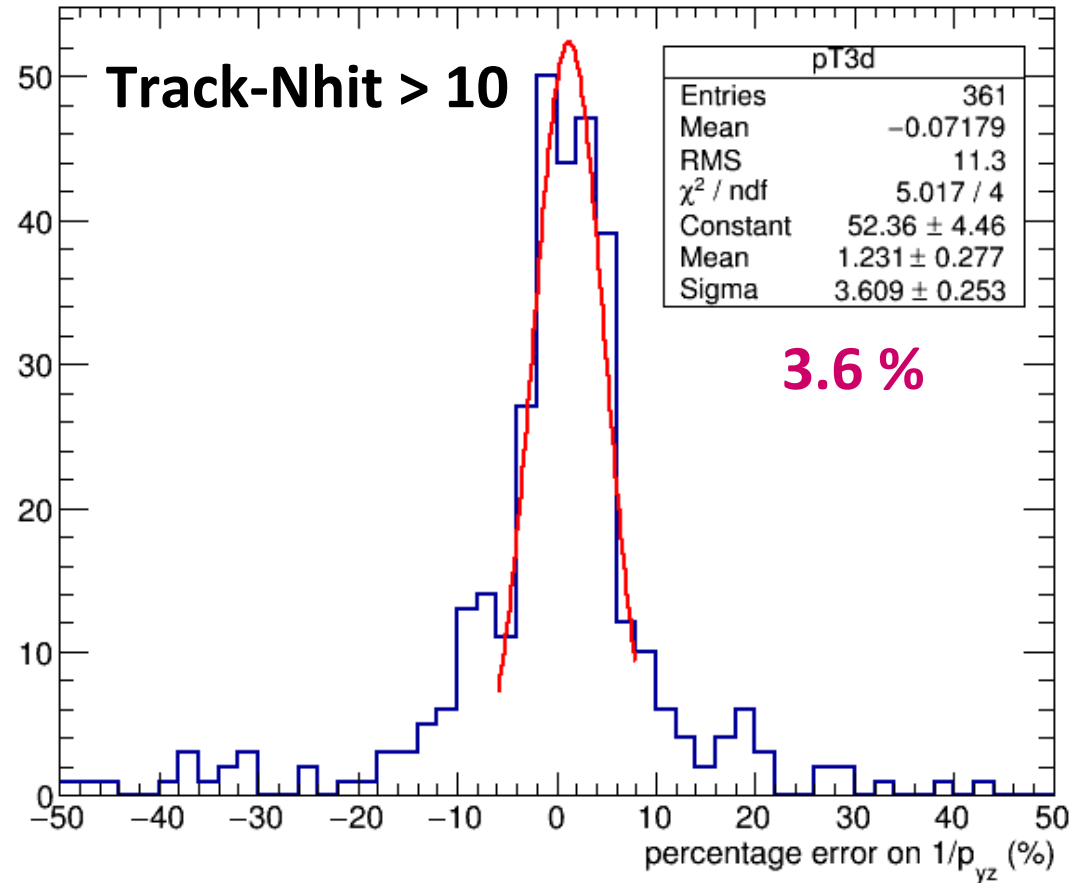
LAr-target layout: event sample (1)

Error on dip-angle (λ)

2.1 mrad

dip3d	
Entries	546
Mean	−0.001298
RMS	0.01232
χ^2 / ndf	1.695 / 2
Constant	88.74 ± 7.85
Mean	−0.0003392 ± 0.0001510
Sigma	0.002142 ± 0.000147

Error on total momentum
$$p = p_{yz} / \cos \lambda$$

3.2 %

p3d	
Entries	608
Mean	1.646
RMS	6.165
χ^2 / ndf	9.631 / 10
Constant	62.92 ± 3.82
Mean	2.147 ± 0.166
Sigma	3.193 ± 0.164

1 reconstructed track on both views

Effect of the background removal
on the neutrino spectrum